

July 17, 2008

MEMORANDUM: Stephanie Coffin, Chief
AP1000 Projects Branch 1
Division of New Reactor Licensing
Office of New Reactors

FROM: Joseph Sebrosky, Senior Project Manager **/RA/**
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SUBJECT: TRIP REPORT – JUNE 23 - 27, 2008, HYDROLOGY-RELATED SITE VISIT
IN SUPPORT OF THE BELLEFONTE COMBINED LICENSE APPLICATION

This report summarizes NRC travel to Knoxville, Tennessee, during the period of June 23-27, 2008, to review surface water hydrology-related components of the Tennessee Valley Authority's (TVA's) safety report associated with the combined license application (COLA) for Bellefonte Units 3 and 4. The attendance list for the meeting is provided in Enclosure 1. Enclosure 2 contains the list of action items from the meeting. The meeting handouts are available in ADAMS under accession number ML081900293. The meeting handouts include an agenda for the meeting and the presentations that were provided to the staff during the week. The handouts also include the following 4 documents that were provided to the staff during the meeting: 1) a simulated open channel hydraulics (SOCH) code user's manual; 2) TVA Technical Report Number 26 describing floods and flood controls in the Tennessee Valley; 3) a report titled "Realistic Assessment of Maximum Flood Potentials" presented at an April 30, 1982 American Society of Civil Engineers meeting; and 4) a TVA report titled, "Predicting the Runoff From Storm Rainfall."

The main purpose of the meeting was for the staff to understand the SOCH code and its supporting codes used by TVA to perform the probable maximum flood (PMF) and dam breach analysis for the Bellefonte Units 3 and 4 COLA. What follows are highlights from the meeting.

Highlights from the Meeting

- 1) Final calculation packages related to the SOCH model and its related 8 sub-models will not be complete and ready for review until late Spring 2009. Considering the complexity of the system and the nature of the SOCH model and its sub-models, the NRC staff indicated it will need a considerable amount of review time following completion of these documents. Many updates to the SOCH model and its inputs are being conducted by TVA to reflect newly available data, changes in operating conditions, reanalysis of existing data, and use of new techniques for generation of model inputs. These include: 1) incorporating new Tennessee River cross-sectional data measured by the US Army Corp of Engineers; 2) recalibration of the SOCH model using the newly-generated cross-section data; 3) updating the operating guide curves in the SOCH model for reservoirs in the TVA system upstream of Bellefonte to reflect the modifications made to the system as a result of a TVA 2004

reservoir operations study; 4) reanalysis of rating-curve data collected from previous physical-modeling studies of the dams and updating the dam rating curves in the SOCH model, and 5) updating of unit hydrographs using newer methods for analysis of floods in the Tennessee River system.

Based on TVA's work the staff expects to review some of the detailed analysis work. A partial list of items the staff are expecting to review include: (a) the calculation packages for the development and update of unit hydrographs including those from the new Bechtel-developed HEC-HMS models for each of the 46 sub-areas that make up the Tennessee watershed above the Bellefonte site; (b) the calculation package(s) related to the SOCH unsteady-flow model including the final bathymetry, rating curves, etc. processed and included in the model; and (c) users guides and calculation packages associated with each of the 8 related sub-models.

TVA proposed that the staff continue to interact with TVA during the development of the calculation packages such that when the final calculation packages and information are available in late Spring of 2009, the staff could quickly assess this information. TVA indicated that it believed that the staff could retain the original milestones for the Bellefonte review schedule provided in the February 15, 2008, letter. TVA indicated that it would be providing a proposed schedule for major milestones associated with the SOCH verification and validation by June 30, 2008.

The staff indicated that in accordance with a March 25, 2008, letter it would be reassessing the hydrology review schedule in July 2008. The staff noted that the schedule proposed by TVA during the site visit is not consistent with the assumptions that were used to develop the original Bellefonte review schedule and that the staff response to TVA's proposal will be provided in the July 2008, letter.

- 2) TVA provided an overview of the verification and validation (V&V) process being used for the SOCH code, its support codes, and the associated inputs. TVA indicated that the V&V check process has uncovered discrepancies including the following:
 - a. At high reservoir elevations, water bypasses Chickamauga Dam and flows out through Dallas Bay (a natural low point in the topography). These flows were not routed downstream of Chickamauga Dam into Nickajack Reservoir per TVA protocols, so that the flows disappeared from the model. Following correction of the discrepancy, TVA staff estimated from a subsequent model run that this error raised the design basis peak water surface elevation at the Bellefonte site by >1 ft above that reported in the (final safety analysis report) FSAR.

TVA's identification of this error resulted in development of a problem evaluation report (PER) in accordance with their quality assurance (QA) program to document the issue. This PER was sent for TVA management review on June 23, 2008.

- b. Several rating curves were incorrect and are being revised based on earlier physical-modeling studies and as-built drawings of the various dam spillways. These curves dictate how much water can be discharged through any particular dam at a given reservoir height and influence the backwater conditions produced by the dam.
- c. SOCH-specified operating rules for the system of dams do not follow the current TVA operational guidelines instituted in 2004. The operating rules are being updated to following the current guidelines based on the 2004 *Reservoir Operations Study*.

TVA indicated that the above changes would result in the Bellefonte site remaining dry under the PMF and dam breach analysis conditions; however, a draft revision to the FSAR with the results from the updated analysis would not be available until December of 2008. The staff noted that the site appeared to be "wet" at the lower end of the band for the site elevation allowed by the inspections, tests, analyses, and acceptance criteria (ITAAC) (see action item 6 in Enclosure 2).

- 3) NRC Staff requested two sensitivity studies be performed following the Safety Site Audit. The first is the peaking of the PMF hydrographs by 20% to account for possible non-linearities not accounted for by the methods used to develop the hydrographs. The second is analysis with 100% runoff of the probable maximum precipitation (PMP) storm. TVA provided preliminary results of the sensitivity run based on a version of the SOCH code that has not yet been verified and validated. TVA indicated that these sensitivity runs will be performed again with the version of the SOCH code that is verified and validated. The preliminary results of the sensitivity runs are as follows:
 - a. Peaking of the unit hydrographs by 20% resulted in little change of the peak flood wave at the Bellefonte site. TVA's suggestion was that the flood peak at Bellefonte was influenced more by precipitation volume rather than timing.
 - b. The use of 100% runoff did change the peak flood elevation at the Bellefonte site. The use of 100% runoff produces a conservative estimate in that none of the water infiltrates into the ground. By making this conservative assumption, the Bellefonte site PMF (neglecting the effects of wind waves run-up, etc.) came within 0.1 feet of flooding. TVA's FSAR Rev 0 submittal stated that a basin-wide loss of 11% of the PMP storm soaks into the soil and does not contribute to runoff (and hence site flooding).
- 4) The infiltration sensitivity test case describe in #3b above resulted in overtopping and failure of several mainstem dams upstream of BLN that did not fail in the analysis reported in the

FSAR Rev 0. Presentations by the TVA staff during the June Workshop discussed some of the intricacies of running SOCH. This also provided an example of the need for an experienced reviewer to run the models to ensure that the results were accurate.

- 5) During the Workshop, NRC staff were not able to review the final version of available users guides and other documentation related to the 8 SOCH sub-models since they have yet to be developed (only the main SOCH program and TRBROUTE sub-model currently have users guide). These sub-models create the river geometry, unit hydrographs, and other important inputs to the SOCH model. During the workshop, introductory training on the set up and running of the SOCH model and several sub-models was provided. TVA indicated that an additional training session for the NRC staff maybe needed to support the staff's understanding of these codes. It was acknowledged by TVA that a considerable effort is needed to conduct one model run (on the order of one week for an experienced user).

Docket Nos.: 52-014 and 52-015

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Enclosures:
As stated

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June 23 – 27, 2008 Site Visit to Knoxville, TN
 To Discuss Hydrology Codes Used to Support the
 Bellefonte Combined License Application
 Attendance List

Name	Organization
Christopher Cook	NRO/DSER/RHEB
Ken See*	NRO/DSER/RHEB
Joe Sebrosky*	NRO/DNRL/NWE1
Rajiv Prasad	PNNL (NRC contractor)
Steve Breithaupt*	PNNL (NRC contractor)
Greg Lowe*	TVA contractor
Ramon Lee*	TVA contractor
Perry Maddux*	TVA/NGD
Karen Ford	TVA/ River Scheduling
Steve Limback*	TVA/ River Scheduling
David Bowling	TVA River Forecast Center
Morgan Goranflo	TVA contractor
Roger Milstead	TVA river scheduling
Jerry Schohl	TVA contractor
Andrea Sterdis	TVA
Bob Taphorn	U.S. Army Corp of Engineers
Pamela J. Nabors	TVA
Steve Amick	TVA
Kit Ng	Bechtel
Fred Locher	Bechtel
Tom Jackson	Bechtel

* denotes an individual that was present at all portions of the site visit

List of Action Items Associated with June 23 – 27, 2008 Site Visit to Knoxville, TN
To Discuss Hydrology Codes Used to Support the
Bellefonte Combined License Application

The Tennessee Valley Authority has the following action items as a result of the site visit:

From Day 1

- 1) TVA is to consider comparing the simulated open channel hydraulics (SOCH) code to the U.S. Army Corp of Engineers HEC-RAS code for unsteady flows.
- 2) TVA is to consider rerunning the case summarized in Figure on page 11 of the Geometry Presentation, such that the simulated reservoir water surface elevations start at the appropriate elevation as opposed to the 570 - 595 level. The starting level will be chosen consistent with the appropriate operating and rating curve.

From Day 2

- 3) TVA is to consider explaining the relationship between the RiverWare code used in the River Forecast Center and the SOCH code.
- 4) TVA is to consider whether revision to the April 17, 2008, white paper will be needed and the regulatory standing of the white paper given that major portions of the white paper should be captured in the hydrology calculation package that is being developed to support the Bellefonte final safety analysis report.
- 5) TVA is to consider another site visit for the NRC staff to learn the codes that support SOCH given that not all of the support codes were available to the staff during the site visit.
- 6) TVA is to review the AP1000 design control document (DCD) for commitments related to the site elevation and consider whether exemptions/deviations from the AP1000 DCD are needed. For example, the inspections, tests, analyses, and acceptance criteria (ITAAC) for site elevation for the AP1000 DCD is 100 feet plus or minus 3 feet 6 inches. According to the current probable maximum flood (PMF) evaluation (and neglecting wind waves, run-up, etc.) the site would be flooded at the lower limits of the band for the ITAAC.
- 7) The infiltration rates that were provided during the site visit are inconsistent with the information provided in Table 2 of the April 17, 2008, white paper. TVA is to consider whether Table 2 of the white paper should be updated.
- 8) TVA is to consider the need to perform sensitivity run #11 associated with the upstream centered 21,400 square mile design storm that TVA presented during the discussion of SOCH runs required to support the BLN COLA review.

- 9) TVA is to consider providing an explanation of the Goodrich semi-graphical method in a revision to the white paper. The staff noted that there is a draft RAI associated with this item.

From Day 3

- 10) TVA is to consider whether the Excel macros or the macro outputs used in the various spreadsheets to build input files for SOCH and associated codes should be captured in the TVA quality assurance program.
- 11) TVA will define the term “controlling,” “non-controlling,” “Phase 1,” and “Phase 2,” in the schedule letter that it intends to provide to the staff. These terms were used in the Schedule presentation provided to the staff on June 25, 2008.
- 12) TVA is to provide reservoir surface area information for the Guntersville, Nickajack, Chickamauga, Watts Bar, and Fort Loudon reservoirs.

From Day 4

- 13) TVA is to consider, as the design basis flood calculation packages are developed in accordance with its quality assurance program, whether electronic files will be created that could be used by the NRC staff to perform confirmatory calculations.
- 14) TVA will consider providing the staff with an overview of the watershed with diagrams that shows how the watershed, tributaries, and river was modeled in SOCH. The SOCH diagrams should be consistent with the material provided in TVA’s “PMF-SOCH Run Sequence” presentation.

The NRC staff took the following actions as a result of the site visit:

- 1) Draft electronic requests for additional information (ERAI) that were provided to TVA in a June 18, 2008, email were discussed during the meeting. The NRC staff took the following actions related to these draft ERAIs:
 - a) The staff will modify draft ERAI 398 question 5 to clarify the question and to address that the statement in the ERAI that “no credit was taken for the spillway gates or adjustable structures during a probable maximum flood,” is not correct.
 - b) The staff will revise ERAI 422 question 3 to delete the first sentence and to replace it with the following three sentences. “TVA should provide diagrams of dam cross sections for: 1) the tributary dams found to be controlling during seismic events, and 2) all main stem dams. The diagrams should clearly show flood levels and assumed sections of the dam that fail and how they are postulated to fail for the given event. TVA should also include a diagram of the Dallas Bay area above Chickamauga Dam such that the diagram shows how at high reservoir levels this area will provide a flow path for bypassing the Chickamauga Dam.”